FAA-E-2592a

SUPPLEMENT 2

FINAL

18 July, 1984

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION SPECIFICATION

MINIMUM SAFE ALTITIUDE WARNING (MSAW)

AND

CONFLICT ALERT (CA)

FOR EN-ROUTE AUTOMATED RADAR TRACKING SYSTEM (EARTS) MOSAIC SOFTWARE

This supplement forms a part of specification FAA-E-2592a dated July 1, 1976, when so specified in specifications, requests for proposals, invitations for bids or contracts.

REQUIREMENTS

EARTS (EARTS-M) operational software and the alarm equipment necessary to provide the alerts to the appropriate control positions. The MSAW and CA functions shall require no more than an additional two 16K memory modules when MSAW data base is 15,000 words or less. For commonality, this mosaic software will be utilized at all EARTS facilities.

1.2 SCOPE

This specification establishes the performance requirements for the operational and support (off-line) software, the alarm equipment, and the component and system testing to be performed to ensure the requirements have been met. This document is intended as a supplement to FAA specification FAA-E-2592a and supplement-1 to specification FAA-E-2592a. EARTS functions not covered or modified by this supplement will be retained.

DOCUMENTATION

2.1 GOVERNMENT SPECIFICATIONS AND STANDARDS

(a)	FAA-E-2592a, Supplement-1	Mosaic Software for En Route Automated Radar Tracking System (EARTS), Supplement-1, December 1982
(b)	FAA-E-2592a	EARTS Specification, July 1, 1976
(c)	NAS-MD-320	Multiple Radar Data Processing, December 17, 1980
(d)	NAS-MD-321	Automatic Tracking, December 17, 1980
(e)	NAS-MD-318	Performance Criteria, December 17, 1980
(f)	NAS-MD-325	Software Design Requirements, April 14, 1980
(g)	NAS-MD-323	Dynamic Simulation of Radar Data, April 14, 1980
(h)	NAS-MD-322	Real Time Quality Control of Radar Data, December 17, 1980
(i)	NASP-5105-15	NAS En Route Stage A - Application Subsystems, (Vol. II)September 24, 1979
(j)	NASP-5149-17	NAS En Route Stage A, Subsystem Design Data, Radar Processing and Tracking Subsystem, December 17, 1980

(o) U.S. Department of Commerce, Coast and Geodetic Survey, Special Publication No. 8 - Formulas and Tables for the Computation of Geodetic Positions, 1952

(p) FAA-STD-21 Configuration Management(Contractor Requirements), August 7, 1981

2.2 SPERRY DOCUMENTS

(a) PX 13417 En Route ATC Tracking Functions Summary, January 5, 1981

(b) PX 12399 Expanded EARTS for Multisensor Tracking with Mosaic Display, July, 1977

(c) ATC 11301 EARTS Tracker Study Report, June, 1981

(d) PX 7971 Multisensor System Design Data, March 8, 1973

(e) ATC 24018 Expanded Anchorage EARTS Operational Program Sizing and Timing Analysis, December 1981

(f) PX 6392 ARTS III Augmented Tracking Study Report, June, 1972

(g) ATC 24007 EARTS Coding Specification, January, 1979

(h) ATC 25007 NY TRACON Coding Specification, October, 1980

(i) ATC 10101 ARTS Enhancement (Phase II) Multisensor Tracking Study Report, May, 1976 (Draft)

(j) ATC 24019 EARTS Mosaic Analysis, Preliminary Report, December, 1981

(k) ATC 24020 EARTS Mosaic Analysis, Final Report, March, 1982

(l) ARTS III-A, EARTS Architecture Expansion Study, October, 1981

Specification, Final, December 1979

(n) PX 11021 — Multisensor Parallel Tracking Level Test and Evaluation Report, August, 1975

(o) ATC 24022 — EARTS MSAW/CA Analysis, March, 1983

2.3 MISCELLANEOUS DOCUMENTS

(a) MTR-6286 — Multisensor Utilization in the Terminal Area, March, 1973, (MITRE)

(b) FPB-T-024 — Multisensor Tracking Study Final Report September, 1975,(APL)

(c) LL Report No. 67 — A Common Coordinate System for the Utilization of Data from Several Radars, September 13, 1954

(d) SR-2 — A Stereographic Coordinate System for the Utilization of Data from Several Radar(MITRE), March, 1959

(e) FN-LX-151 — Lincoln Laboratory, Error Minimization in the Stereographic Projection, April 3, 1958

(f) 6M-3474 — Lincoln Laboratory, Memorandum, SAGE System Data Conversion and Transformation, June 21, 1955

(g) — AERA Concept Description, Draft of Section 3, AERA System Description, July 1980 (MITRE Corp.)

(h) 9805-T3-CP53 — Computer Program Functional Specification for the Development of EARTS On-Line Certification, October 9, 1981 (IBS)

(i) 9805-T2-PDS2 — Program Organization and Design Specification for On-Line Certification of EARTS, March 16, 1981 (IBS)

(j) DARC-MD-320 — Multiple Radar Data Processing, February 17, 1981

This specification provides the requirements for adding the Terminal Safe Altitude Warning (MSAW) and the Conflict Alert (CA) functions to a Mosaic EARTS (EARTS-M) operational software program. The system shall be capable of providing the necessary controller alerts to support both the terminal area air traffic control and en-route air traffic control functions. The functional additions to EARTS-M include expansion of both the operational and support software. The functional areas covered by this specification are as follows:

(a) Operational Software changes include:

(1) Addition of MSAW

(2) Addition of CA

(3) Addition of Altitude Tracking

(4) Change in Display Output

(5) Additional Keyboard Entries

(6) Additional Data Extraction

(7) Additional Adaptation Data

(b) Support Software Changes include:

(1) Additional Data Reduction

(2) Additional Data Base Generation and Maintenance

following:

(a) Current altitude of the track; and

(b) Current rate of change in the altitude (altitude velocity).

The Altitude Tracker shall be capable of determining current altitude and altitude velocities for aircraft flying level paths as well as aircraft in climb/descent status. Smoothing parameters used and rationale for these parameters shall be presented by the contractor at time of the critical design review. Input to the Altitude Tracker shall consist of a valid Mode-C or controller entered assigned, interim, and reported altitude which has been associated with a track.

(c) The Altitude Tracker shall have the capability to determine reasonableness of the Mode-C report. Reasonableness checks are as follows:

(1) Allow only Mode-C reports which are between a maximum and minimum altitude value. Values to be defined at time of system requirements review.

(2) Define as unreasonable, Mode-C reports which would represent an excessive change in altitude or altitude velocity between successive track correlations. Parameters used and rationale for these parameters shall be presented by the contractor at time of the critical design review.

Detection of aircraft in transition(e.g., from level flight to ascent or descent) shall be required for the Altitude Tracker to support the MSAW and CA functions. Altitude velocity is a measure of this transition and the Altitude Tracker shall be responsive to such transitions. Altitude velocity shall be calculated based on an aircraft's altitude report. The altitude velocity shall then be used along with the horizontal velocity to project conflict with terrain.

3.1.2 Minimum Safe Altitude Warning (MSAW)

The MSAW function shall use aircraft three dimensional position and velocities to determine potential conflict with terrain and obstructions. It shall alert the controllers both visually and aurally to these potential conflicts, allowing time to advise aircraft of evasive actions necessary to resolve the conflict. MSAW shall be added to the mosaic EARTS operational software program. It shall be modular in concept and shall not degrade EARTS tracking. Only aircraft with Mode-C capability or controller entered assigned, interim, and reported altitudes which are associated with an EARTS controller shall be considered elilgible for MSAW processing.

3.1.2.1 General Terrain Monitoring Algorithms

A potential terrain hazard shall be detected by comparing the current and predicted altitude with a minimum altitude value. The predicted altitude shall be determined as a function of the altitude change rate and a warning time parameter. Warning time parameter is a system parameter and is based on projecting ahead the current flight path "n" parameter seconds look-ahead time. The warning time parameter shall be chosen such that a timely determination of potential conflict can occur without prediction errors building to cause a false conflict determination.

The general terrain map shall be modeled by convex polygons overlaying the controlled airspace area of interest. Enclosed polygons shall be at either a higher or lower altitude. Each polygon shall have a minimum safe altitude associated with it.

The present track position and the MSAW predicted track positions within two minutes (system parameter) shall be used to identify the polygons to be used for altitude comparison. The predicted track position shall be based on the current track position and the current track velocity.

All aircraft which are associated with an EARTS-M controller and are currently in or predicted into the airspace of an EARTS defined airport area shall be considered for Approach Path Monitoring. This function will be described in paragraph 3.1.2.2.

The generation of a controller alert shall be based upon the repeated detections (system parameter) of a hazardous condition. When a hazardous condition is determined by the General Terrain Monitoring function, both aural and visual alerts shall be given to the controller. These alerts are described in paragraph 3.1.4 and paragraph 3.1.5.

comparing the current and predicted altitude with a minimum altitude value. The predicted altitude shall be a function of the altitude change rate and a warning time parameter. Due to the fact that Approach Path Monitoring will be monitoring a substantial number of low-flying, maneuvering aircraft, the approach prediction time (system parameter) shall be nominally one minute.

The airport airspace is defined by a convex polygon and an altitude above the airport encompassing all runways at the airport. The algorithm shall detemine whether the aircraft is arriving/departing the airport airspace and if so, which runway it is associated with. Utilizing this information, the current and predicted altitude shall be compared to all minimum safe altitude values which are defined along the predicted approach path. Overflights shall be appropriately categorized and then not processed by approach path monitoring.

The generation of a controller alert shall be based upon the repeated detections of a hazardous condition. When a hazardous condition is determined by the Approach Path Monitoring function, both aural and visual alerts shall be given to the controller. These alerts are described in paragraph 3.1.4 and paragraph 3.1.5.

3.1.3 Conflict Alert (CA)

Conflict Alert uses predicted aircraft position to monitor potentially hazardous conflicts between aircraft, and to alert the controller when safe separation criteria are being violated. The alert shall be presented both visually and aurally, allowing time to advise the aircraft of actions necessary to resolve the conflict.

Only aircraft with Mode-C capability or controller entered assigned, interim and reported altitude shall be eligible for CA processing. CA alerts shall only be detected when one of the aircraft in a conflicting pair is associated with an EARTS controller. The EARTS controller shall be able to apply avoidance procedures to the aircraft equipped with Mode-C or the aircraft with controller entered assigned, interim, or reported altitude.

potential conflict exists. If the number of tracks in the system is N, then the number of track pairs is $(N^2-N)/2$. The number of track pairs becomes extremely large as the number of tracks increases. To do complete conflict alert processing on all these pairs would require so much processing so as to overload the system. Some method must therefore be used to reduce this number of pairs to a manageable level. That is, some method must be used which eliminates those pairs that could not possibly be in conflict. The rationale to be used in the design of the Primary Filter shall be presented to the FAA for approval at the systems requirements review. FAA shall also approve the contractor's final approach to the Primary Filter algorithms during the critical design review.

3.1.3.2 Conflict Detection Algorithm

The Conflict Detection Algorithm shall determine if a conflict situation exists for each track pair that passes through the Primary Filter. The detection algorithms shall use the lateral position and velocity data from the EARTS-M tracker, and the altitude and altitude velocity from the Altitude Tracker described in paragraph 3.1.1. The algorithms shall be capable of handling multiple conflict situations, parallel approach situations, converging approach situations, maneuvering conflict situations and both current and predicted violations. The algorithms shall be parameterized in such a manner as to allow the algorithms to be sensitized to unique site conditions.

The generation of a controller alert shall be based on repeated detections (system parameter) or predictions (system parameter) of aircraft separation violation. The number of repeated detections (system parameter) shall be chosen such that a timely determination of potential conflict can occur without prediction errors building to cause a false conflict determination. Quantization of the separation violation shall be presented by the contractor to the FAA for approval at time of system requirements review and further refined during the critical design review. The controller alerts are described in paragraph 3.1.4 and paragraph 3.1.5.

The following display formats shall be provided.

3.1.4.1 Full Data Block (FDB)

MSAW

When an aircraft has been projected as violating or currently is violating a minimum altitude, the character "MSAW" shall be displayed in field 7 of the FDB. The characters "MSAW" shall blink and the field shall time-share with other data items in field 7 on a cyclic basis. A high intensity vector from the track position to the point of MSAW intrusion shall be displayed. The adapted minimum warning altitude for the area when the conflict is predicted to occur shall be displayed at the point of conflict. This altitude shall also be blinking.

The controller shall have the capability to select/inhibit the display of the high intensity vector and the adapted minimum warning altitude at his control position.

When an aircraft is inhibited from MSAW processing the type of inhibit shall be indicated by the indicators "MOFF" (MSAW alerts are suppressed for a specific aircraft until either the alert situation is terminated or the aircraft is handed-off) or "MIFF" (MSAW alerts are permanently suppressed for a specific aircraft) in field 7 of the FDB.

CA

A controller shall be alerted to a conflict situation between two tracks as follows:

(a) The blinking characters "CA" shall appear in field 7 of the full data block of both tracks.

(b) Vectors shall be displayed from each track extending in the direction of the heading. Controller shall have the capability to select/inhibit the vectors at his control position.

3.1.4.2 Priority Scheme

Contractor shall develop a priority allocation display system for display of MSAW/CA FDBs. This allocation system shall consist of dropping lessor priority data such as single symbols. Priority allocation system shall be discussed during the system requirements review with final decision made during the critical design review.

MSAW

Each line for the MSAW alert shall be composed of the following fields:

Field 1 - Contains the aircraft identification

Field 2 - Contains the 3 character aircraft reported altitude or the characters "CST"

Field 3 - Contains the characters "LOW ALT"

CA

Each line for the CA alert shall be composed of the following fields:

Field 1 - Contains the aircraft identification of the first aircraft

Field 2 - Contains the conflict violation altitude

Field 3 - Contains the aircraft identification of the second aircraft (beacon code if unassociated)

The most recent tracks to enter alert status shall be displayed on line 1. Up to five (system parameter) alerts may displayed in the list before the message "OVERFLOW" is displayed. If a track is in MSAW alert status and becomes a coast track, the characters "CST" shall replace the reported altitude displayed in field 2. If MSAW or CA times-out for a particular track, or an MSAW or CA inhibit keyboard entry is made, all alert presentations and alarms shall be deleted.

All above defined visual display items shall be under controller display option control. Keyboard entries to inhibit or enable display functions for MSAW or CA are discussed in paragraphs 3.1.6.1, 3.1.6.2, and 3.1.6.3.

3.1.4.4 System Data Area

If MSAW has been inhibited for the system or for a particular controller position, a message shall be displayed in the system data area. When "MSAW OFF - GT" is displayed, General Terrain Monitoring is off. When "MSAW OFF - AP" is displayed, Approach Path Monitoring is off. When "MSAW OFF - AP GT" is displayed, both General Terrain Monitoring and Approach Path Monitoring are turned off. If CA has been inhibited for the system or for a particular controller position, a message shall be displayed in the system data area. When "CA OFF - AP" is displayed, Airport Monitoring is off. When "CA OFF - ER" is displayed, En Route Monitoring is off. When "CA OFF - AP ER" is displayed, both Airport Monitoring and En Route Monitoring are turned off.

3.1.5 Aural Alarm Output

An Aural Alarm Control Unit (AACU) shall provide an audible alarm for MSAW and CA alerts. This unit shall be under operational program contol and allow isolation of an alarm to a specified area of the control room

Whenever either an MSAW or CA alert is presented, the aural alarm device shall be sounded from one to thirty (site parameter) seconds.

The aural alarm control unit shall be able to handle up to 6 alarms. Of these six alarms, a maximum of five may be remote alarms.

Training tracks shall not activate MSAW or CA aural alarms.

3.1.6 Keyboard Entries

The following paragraphs describe the keyboard operational functions necessary to control the MSAW/CA functions.

3.1.6.1 Common MSAW/CA Keyboard Entries

(a) Relocate LA/CA Alert List at this control position. This is a single alert list containing LA/CA alert data. The format of this entry and its validation criteria are as follows:

Entry Format:

(1) Depress Multi-Function - T(space)M
(2) Depress SLEW ENTER at desired location

Validation Criteria:	Resulting Error Message:
Extraneous Data Entered	FORMAT

(1) Depress Multi-Function - T(space)M
(2) Depress ENTER

Validation Criteria:	Resulting Error Message:
M not entered correctly	FORMAT

3.1.6.2 MSAW Keyboard Entries

Controller PVD Entries:

(a) Specific Instance Inhibit/Select Track for MSAW Output. The format of this entry and its validation criteria are as follows:

Entry Format:

(1) Depress F12 Key (MA)
(2) Enter OK: Optional
(3) Depress SPACE (if OK entered)
(4) Enter Aircraft Identity: ACID, discrete beacon code, or SLEW coordinates
(5) Depress ENTER(or SLEW ENTER as appropriate)

Validation Criteria:	Resulting Error Message:
OK is entered from a maintenance or BANS position	ILL FNCT
Invalid identity data is entered	FORMAT
No FDF corresponds to the entered identity	ILL TRK
Extraneous data is entered	FORMAT
Identified FDF is not controlled by enterer (or the enterer's paired position) and OK is not entered	ILL POS
The identified FDF is in flight plan, store, or handoff status	ILL TRK
A/C not in alarm status	ILL TRK

(2) Depress #
(3) Depress SPACE (Optional)
(4) Enter ON or enter OFF
(5) Depress ENTER

Validation Criteria	Resulting Error Message:
# ON or # OFF entered incorrectly	FORMAT
Enterer is paired with two positions	ILL FNCT
Extraneous data is entered	FORMAT

Supervisory PVD Entries:

(a) Enable/Disable MSAW processing for a specific track, indefinitely.

The format of this entry and its validation criteria are as follows:

Entry Format:

(1) Depress F12 Key (MA)
(2) Enter OK - Optional
(3) Depress SPACE (if OK entered)
(4) Enter Aircraft Identity: ACID, discrete beacon code, tabular line identifier, or SLEW coordinates
(5) Depress SPACE (if SLEW not entered)
(6) Enter I
(7) Depress ENTER or SLEW as appropriate

Validation Criteria:	Resulting Error Message:
OK is entered from a maintenance or BANS position	ILL FNCT
Invalid identity data is entered	FORMAT
Invalid tab-line identification entered	ILL LINE
Invalid position in tab-line identification entered	ILL POS
Single character tab-line identification entered and enterer is paired with two positions	ILL FNCT
No FDF corresponds to the entered identity	ILL TRK
Extraneous data is entered	FORMAT
Identified FDF is not controlled by the enterer (or the enterer's paired position) and OK is not entered	ILL POS
I not entered correctly	FORMAT

Enter TK MSAW ON, or
TK MSAW OFF

Validation Criteria:	Resulting Error Message:
TK not entered correctly	CDT ILL FORMAT
MSAW ON or MSAW OFF not entered correctly	OPRND ERR

(b) Enable/disable the display of MSAW warnings (Approach Monitoring and General Terrain Monitoring) for the individual control positions. The format of this entry and its validation criteria are as follows:

Entry Format:

(1) Enter TK MSAW
(2) Depress SPACE
(3) Enter ON or OFF
(4) Depress SPACE
(5) Enter GT or AP: Optional - If neither GT (General Terrain) nor AP(Approach Path) is entered, both are enabled/disabled
(6) Depress SPACE
(7) Enter ALL or a controller symbol
(8) Depress SPACE: Optional and repeatable (with 9)
(9) Enter a controller symbol
(10) Depress ENTER

If ALL is not entered, only those control positions specified are enable/disabled. If ALL is entered, all control positions are enabled/disabled except those specified. If either GT or AP is specified, the status of the other is unchanged.

Validation Criteria:	Resulting Error Message:
TK not entered correctly	CDT ILL FORMAT
MSAW ON or MSAW OFF entered incorrectly	OPRND ERR
GT, AP, or ALL entered incorrectly	OPRND ERR
Invalid controller symbol entered	ILL POS
Extraneous Data entered	OPRND ERR

follows:

Entry Format:

Enter TK MSAW

Validation Criteria	Resulting Error Message:
TK not entered correctly	CDT ILL FORMAT
MSAW not entered correctly	OPRND ERR

(b) Request a printout at this CDT of the tracks that are currently inhibited from MSAW or are currently in MSAW alarm status: The format of this entry and its validation criteria are as follows:

Entry Format:

Enter TK MSAW TRACKS

Validation Criteria	Resulting Error Message:
TK not entered correctly	CDT ILL FORMAT
MSAW TRACKS not entered correctly	OPRND ERR

are as follows:

Entry Format:

(1) Depress F11 Key (CA)
(2) Enter OK: Optional
(3) Depress SPACE (if OK entered)
(4) Enter Aircraft Identity: ACID, discrete beacon code, or SLEW coordinates
(5) Depress SPACE (if slew not entered)
(6) Enter Aircraft Identity: ACID, discrete beacon code, or SLEW coordinates
(9) Depress ENTER or SLEW as appropriate

Validation Criteria:	Resulting Error Message:
OK is entered from a maintenance or BANS position	ILL FNCT
Invalid identity data is entered	FORMAT
No FDF corresponds to either entered identity	ILL TRK
No FDF corresponds to an entered ACID or discrete beacon code	ILL TRK
Extraneous data is entered	FORMAT
Neither identified track is controlled by the enterer (or the enterer's paired position) and OK is not entered	ILL POS
Either identified FDF is in flight plan, suspend, or store status	ILL TRK
No ADF corresponds to an entered SLEW	ILL TRK
The same track is identified twice	ILL FNCT
A/C not in alarm status	ILL TRK
Track pair inhibit table is full	ILL FNCT

(1) Depress F11 Key (CA)
(2) Depress #
(3) Depress SPACE (Optional)
(4) Enter ON or Enter OFF
(5) Depress Enter

Validation Criteria	Resulting Error Message:
# ON or # OFF entered incorrectly	FORMAT
Enterer is paired with two positions	ILL FNCT
Extraneous data is entered	FORMAT

Supervisory PVD Entries:

(a) Track Inhibit/Select - To inhibit (or select) all conflicts for a specified track indefinitely. The format of this entry and its validation criteria are as follows:

Entry Format:

(1) Depress F11 Key (CA)
(2) Enter OK: Optional
(3) Depress SPACE (if OK entered)
(4) Enter Aircraft Identity: ACID, discrete beacon code, tabular line identifier, or SLEW coordinates
(5) Depress SPACE (if SLEW not entered)
(6) Enter I
(7) Depress ENTER or SLEW as appropriate

Validation Criteria:	Resulting Error Message:
OK is entered from a maintenance or BANS position	ILL FNCT
Invalid identity data is entered	FORMAT
Invalid tab-line identification entered	ILL LINE
Invalid position in tab-line identification entered	ILL POS
Single character tab-line identification entered and enterer is paired with two positions	ILL FNCT
No FDF corresponds to entered identity	ILL TRK
Extraneous data is entered	FORMAT
The identified track is not controlled by the enterer (or the enterer's paired position) and OK is not entered	ILL POS
No ADF corresponds to an entered SLEW	ILL TRK

(3) Depress SPACE (if OK entered)
(4) Enter Aircraft Identity: ACID, discrete beacon code, tabular line identifier, or SLEW coordinates
(5) Depress SPACE (if SLEW not entered)
(6) Enter Aircraft Identity: ACID, discrete beacon code, tabular line identifier, or SLEW coordinates
(7) Depress SPACE (if SLEW not entered)
(8) Enter P
(9) Depress SLEW or ENTER as appropriate

Validation Criteria:	Resulting Error Message:
Track pair inhibit table is full	ILL FNCT
OK is entered from a maintenance or BANS position	ILL FNCT
Invalid identity data is entered	FORMAT
Invalid tab-line identification entered	ILL LINE
Single character tab-line identification entered and enterer is paired with two positions	ILL FNCT
No FDF corresponds to either entered identity	ILL TRK
No FDF corresponds to an entered ACID or discrete beacon code	ILL TRK
Extraneous data is entered	FORMAT
Neither identified track is controlled by the enterer (or the enterer's paired position) and OK is not entered	ILL POS
No ADF corresponds to an entered SLEW	ILL TRK
The same track is identified twice	ILL FNCT
P not entered correctly	FORMAT

Enter TK CA ON or
TK CA OFF

Validation Criteria:	Resulting Error Message:
TK not entered correctly	CDT ILL FORMAT
CA ON or CA OFF not entered correctly	OPRND ERR

(b) Enable/Disable the display of CA warnings (Airport Monitoring and En Route Monitoring) for the individual control positions. The format of this entry and its validation criteria are as follows:

Entry Format:

(1) Enter TK CA
(2) Depress SPACE
(3) Enter On or OFF
(4) Depress SPACE
(5) Enter ER or AP: Optional - If neither ER (en route) nor AP (airports) is entered, both are enabled/disabled.
(6) Depress SPACE
(7) Enter ALL or a controller symbol
(8) Depress SPACE: Optional and repeatable (with 9)
(9) Enter a controller symbol
(10) Depress ENTER

If ALL is not entered, only those control positions specified are enabled/disabled. If ALL is entered, all control positions are enabled/disabled except those specified. If either ER or AP is specified, the status of the other is unchanged.

Validation Criteria:	Resulting Error Message:
TK not entered correctly	CDT ILL FORMAT
CA ON or CA OFF entered incorrectly	OPRND ERR
ER, AP or ALL entered incorrectly	OPRND ERR
Extraneous data entered	OPRND ERR
Invalid Controller Symbol entered	ILL POS

Enter TK CA

Validation Criteria:	Resulting Error Message:
TK not entered correctly	CDT ILL FORMAT
CA not entered correctly	OPRND ERR

(b) Request a printout at this CDT of the tracks that are currently inhibited from CA or are currently in CA alert status: The format of this entry and its validation criteria are as follows:

Entry Format:

Enter TK CA TRACKS

Validation Criteria:	Resulting Error Message:
TK not entered correctly	CDT ILL FORMAT
CA TRACKS not entered correctly	OPRND ERR

Entry Format:

(1) Depress F15 Key (TG).
(2) Enter Target ID (0-63 or SLEW coordinates).
(3) Depress N.
(4) Enter Airport ID.
(5) Enter Runway ID.
(6) Depress ENTER or SLEW as appropriate.

Validation Criteria:	Resulting Error Message:
Enterer is not in Training	ILL FNCT
Incorrect Format/Invalid Data	FORMAT

(b) Inhibit training target termination (missed approach): The format of this entry and its validation criteria are as follows:

Entry Format:

(1) Depress F15 Key (TG).
(2) Enter Target ID (0-63 or SLEW coordinates).
(3) Depress #.
(4) Depress ENTER or SLEW as appropriate.

Validation Criteria:	Resulting Error Message:
Enterer is not in Training	ILL FNCT
Incorrect Format/Invalid Data	FORMAT

3.1.7 Data Extraction

The capability shall exist for on-line data extraction for the Altitude Tracking, MSAW and CA functions. This data extraction shall be accomplished by modification to the Continuous Data Recording function currently existent in the EARTS operational program. Definition of method and identification of data for extraction is discussed in the following paragraphs.

(a) System time of current processing
(b) Track number with ACID, if available
(c) Current aircraft altitude
(d) Rate of altitude change (altitude velocity)

3.1.7.2 MSAW Data Extraction

MSAW Alarm Data shall be extracted when a track has violated or is predicted to violate either general terrain or approach path criteria. Data to be extracted shall at least consist of the following data items:

(a) Notation of whether alarm is associated with a General Terrain or Approach Path Warning
(b) System time of the violation
(c) Aircraft identification
(d) Minimum safe altitude
(e) Coordinates of the violation point
(f) Coordinates of current aircraft position and current velocity
(g) Current aircraft altitude and altitude velocity
(h) Number of the display controlling the aircraft.

3.1.7.3 CA Data Extraction

Extracted data items for aircraft in conflict shall consist of at least the following items:

(a) System time
(b) Each aircraft's track number, and if available ACID and beacon code
(c) Each aircraft's coordinates and velocity
(d) Each aircraft's altitude velocity and altitude
(e) Each aircraft's associated controller ID.
(f) Data on actual violation.

The amount of data listed for extraction may cause system performance degradation, especially if extraction is performed for all aircraft passing the primary filter. Contractor shall propose keyboard entry(s) which will preclude system performance degradation.

The following parameters are identified only as a possible list of parameters to be used in the definition of the MSAW and CA functions. It shall be at the discretion of the contractor to modify/add/delete from this list and to define acronyms and value limits to each parameter used. An updated list shall be provided to FAA for review and approval at the critical design review and throughout the development of the MSAW and CA functions:

(a) MSAW High Altitude Filter - Defines the altitude above which MSAW will not process Mode-C tracks or controller entered assigned, interim, and reported altitudes.
(b) Inhibit Areas - Specifies those areas, if any, in which tracks will be inhibited from MSAW processing.
(c) Number of airports.
(d) Number of runways at each airport and their coordinates.
(e) Indication of the association of each aural alarm with specific control positions.
(f) Number of aural alarms.
(g) Approach Path Prediction Warn Time.
(h) General Terrain Prediction Warn Time.
(i) Validation threshold to display alert and initiate aural alarm.
(j) Time to cease display after violation has ended.
(k) Aural alarm duration.
(l) Conflict Alert Separation parameters.
(m) Nominal look ahead parameters (system parameters) are as follows:

En-Route	Terminal
MSAW - 2 minutes	MSAW - 30 seconds
CA - 2 minutes	CA - 40 seconds

These are the maximum times associated with applying the MSAW and CA algorithms for predicting the occurrence of a MSAW or CA violation.

The operational software modifications for the MSAW and CA functions shall be scheduled into the EARTS-M lattice structure in such a fashion as to eliminate data interference with other EARTS-M tasks. Provisions shall be made to prevent system time-outs such as monitor clock interrupts as well as to provide an even distribution of processor utilization within the MPE scheduler lattice and cycle framework. This should be accomplished by reducing memory queuing and processor wait-time due to post-task requirements as well as incorporating any other programming and/or data base arrangement techniques that would be practical to implement. The methods use must be designed to prevent any MSAW and CA data processing loss plus they shall have sufficient excess capacity to allow for future systems expansion.

A description of and rationale for these provisions in written form shall be provided and shall inclulde but not be limited to the following:

(a) Special programming techniques and data base arrangements used with a written explanation as to how and why they were chosen

(b) MPE lattice and cycle configuration used with written explanations as to approaches taken in developing the particular configurations chosen.

(c) Test methods and results used to justify or reject a particular lattice and/or cycle configuration.

(d) General guidelines used in the design, development and optimization of the configurations including any timing studies and their results.

(e) A written general explanation of the philosophy of multi-processing task scheduling design in sufficient detail to give the reader a starting point and general approach to be taken in developing or changing a lattice/cycle configuration.

(f) A list of mapping restrictions for the debug and non-debug versions of the EARTS-M system with MSAW and CA.

(g) A written explanation of what to look for, what to avoid, when adding/deleting tasks, increasing/decreasing track file sizes, adding/deleting on-call programs, adding sensors and making any minor or major modifications to the delivered system. This write-up shall include what effect the various built-in system constraints such as mapping restrictions, lattice structure, system timing, data base sizing, will have in the implementation of any modifications including memory queuing and lattice/cycle modifications.

impact on the exisiting EARTS-M lattice structure. The CA and MSAW functions shall be scheduled within the lattice structure to eliminate data interference with existing EARTS-M tasks. Provisions shall be made to prevent system time-outs by the MPE, and to provide a more even distribution of processing times within lattices. This method shall be designed to prevent any data processing loss.

No degradation of EARTS system throughput will be acceptable.

The judicious use of additional methods of data protection may be used in addition to the MPE lattice structure to ensure protection from multiple tasks accessing the same data files simultaneously. Case must be taken to ensure that the employed method does not slow down the EARTS-M system at track capacity and that the system will have excess track processing capacity embedded within its design for possible future expansion.

A written description of the initial design rationale and selection process shall be presented during the system requirements review with final decision made during the critical design review. Final written documentation shall be delivered during acceptance testing.

3.1.9.3 Operational Data Protection

Test and Sets, or a similar type of data protection, shall be used in addition to the MPE lattice structure as required to insure protection from multiple tasks accessing the same data files simultaneously. The operational software design shall addres the use of test and sets, and how their implementation will insure that all data files are protected. A description of and the rationale for the use of test and sets shall be provided. While test and sets can be utilized to protect data, the test and sets should not be allowed to cause system time-outs, e.g., if a file has been test and set, then processing should go on to the next file and come back to the test and set file after other files have been processed.

(b) MSAW processing shall not exceed 30 percent of an IOPB for a maximum number of aircraft within the area of jurisdiction of 350 aircraft with 75 percent associated tracks with an available altitude.

(c) MSAW shall not delay EARTS-M tracker throughput.

(d) MSAW shall not increase response time of other EARTS functions.

(e) MSAW shall present an alert at least 20 seconds prior to a violation 95 percent of the time for which 3 consecutive scans of data indicate an alert should be given.

(f) MSAW shall miss no more than 0.01 percent of all violations for which 3 consecutive scans of data indicate an alert should be given. The 0.01 percent figure is the basis for establishing a maximum false alarm rate.

CA Performance

(a) CA program shall process a capacity of 700 tracks.

(b) CA processing and data base shall not exceed 170 percent of an IOPB for a maximum number of aircraft within the area of jurisdiction of 350 aircraft with 75 percent associated tracks with an available altitude.

(c) CA shall not delay EARTS-M tracker throughput.

(d) CA shall not increase response time of other EARTS functions.

(e) CA shall present an alert within 20 seconds prior to a violation 95 percent of the time for which 3 consecutive scans of data indicate an alert should be given.

(f) CA shall miss no more than 0.01 percent of all violations for which 3 consecutive scans of data indicate an alert should be given. The 0.01 percent figure is the basis for establishing a maximum false alarm rate.

3.2.1 Data Reduction

The current EART off-line data reduction program, CDR Editor, shall be modified to reduce the extracted data outline in paragraph 3.1.7. The CDR Editor shall provide the necessary functions to assist in the analysis of the performance of the Altitude Tracking, MSAW and CA functions, and to aid ATC personnel in the post incident analysis of warning events. All currently defined capabilities to filter output data shall be applied to the new defined extraction data classes and those filters deemed applicable to each extraction data class shall be defined at the critical design review.

3.2.2 Data Base Generation and Maintenance

A new off-line program shall be provided to facilitate generation and maintenance of geographical data. This program shall utilize the following Input/Output devices:

(a) A PVD to display maps and to generate the data through keyboard entries defined by the contractor.

(b) A disk on which to store the data (for later reference).

(c) A printer to list the maps for verification

(d) A Magnetic tape unit to generate tapes so that the Calcomp plotter at FAATC can provide maps as needed.

All geographic reference points, such as sensors, shall be enterable as latitude/longitude or as range/azimuth from a known reference(i.e., radar, VOR). The symbols for these reference points shall be displayed on the PVD (in coordinates of the stereographic plane) as they are defined. The capability to add, delete, change, and move symbols shall be provided. Furthermore, the addition or deletion of a sensor shall not require redefinition of these symbols; i.e., a minimal number of entries shall result in the repositioning of the symbols relative to the new stereographic plane. The range and offset switches shall havae the same usage as they have in the operational program. Usage of the trackball shall be allowed to define a position. The coordinates of the trackball shall be displayed in a readout area on the PVD as a latitude/longitude or range/azimuth from an operator-defined reference so that the position can be verified. The following paragraphs describe the functional capabilities of this program relative to specific map data.

would be by the operational program.

3.2.2.2 MSAW Data Base

The MSAW function requires the definition of runways, airport areas, and altitudes associated with either polygons or mosaic map areas. Runway definition shall be accomplished by entering the coordinates of one of the runway endpoints or the runway centerpoint, in latitude/longitude or range/azimuth from a known reference point. The direction, length of the runway in feet, and the runway identity shall be specified. The runway heading relative to magnetic north (not necessarily the approach headings) shall be temporarily displayed in a readout area as well as the runway in its relative position. These runway coordinates can then be used as a starting point for displaying the appropriate symbology s part of the geographic maps. Each airport area shall be defined automatically so that it envelops all of the manually defined runways (and their assumed approaches) at that airport. The definition of polygons shall be allowed using the following two methods:

(a) A series of three to 15 vertices that forms a convex polygon.

(b) By specifying a regular polygon of three to 15 vertices circumscribed about a circle where the keyboard entry specifies the number of vertices, the center of the circle, the radius of the circle, and the number of degrees to rotate the polygon.

The association of altitudes to square bins shall be allowed using the following three methods:

(a) By specifying a single bin.

(b) By specifying a partial (or whole) row (or column) of bins (the output of which is the same as entering each of the bins individually).

(c) By specifying as convex polygon that intersects with or envelops several bins (this polygon is identical to those polygons defined above but it is not saved for later reference; it merely facilitates the association of one altitude to several bins).

accomplished by entering the coordinates of one of the runway endpoints or the runway centerpoint, in latitude/longitude or range/azimuth from a known reference point. The direction, length of the runway in feet, and runway identity shall be specified. Each airport area shall be defined automatically so that it envelops all of the manually defined runways and their assumed approaches. Special CA inhibit areas/ploygons (CA inhibit function whereby the controller is able to selectively inhibit aircraft in certain areas such as at or near airports or other specified areas) may be described by using the following two methods:

(a) By specifying a series of three to 15 (4 bits) vertices that form a convex polygon.

(b) By creating a regular polygon, the number of vertices of which (three to 15) will be entered from the keyboard, which will be circumscribed about a circle whose center and radius will be entered from the keyboard.

3.2.2.4 Mosaic Map Data Base

The entire coverage area is divided into squares. Each square in the mosaic area is 16 NMI on a side. The capability to specify and display the following items for each area shall be provided:

(a) Preferred Sensor: The correlated, transformed coordinates of the preferred sensor are used for display output.

(b) Supplemental Sensor: The sensor associated with the second EARTS track, used to support the preferred track, to smooth mosaic boundary transitions and to provide terminal ATC tracking data.

(c) Backup Sensor: The sensor replacing the supplemental (or preferred if the supplemental is an ASR) when the sensor fails.

(d) Preferred Primary: The sensor used for radar only reports if the preferred sensor is a beacon-only.

(e) Terminal Indicator: Identifying the supplemental as an ASR used for terminal ATC.

(f) Altimeter Setting: An index defining which of 64 correction factors to be used for Mode-C data.

(g) RTQC Data: Identifies various pairs of the previously defined sensors which can be used for sensor registration analysis, where registration analysis is assigned per radar pair not by radar sort box.